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Title: METHOD OF FORMING PARTIAL REVERSE ACTIVE MASK

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Commissioner:

I hereby, confirm that the English translation enclosed herewith is an accurate translation of Taiwanese Application No. 87105966, whose priority date is claimed by the US parent Application (U.S. Pat. App. Serial No. 09/075,618) of the above-captured US Application.

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date 2003, 11. 4

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1. Title: CHEMICAL-MECHANICAL POLISHING FOR SHALLOW TRENCH ISOLATION

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5. Description of the Invention

The invention relates to a chemical-mechanical polishing (CMP) method applied in shallow trench isolation (STI), and more particular, to a chemical-mechanical polishing method incorporated with a partial reverse active mask applied in shallow trench isolation.

For a very large scale integration (VLSI) or even an ultra large scale integration (ULSI), chemical-mechanical polishing is the only technique that provides global planaration. Since this technique greatly reduces feature size of an integrated circuit, the manufacturers rely on this technique for planarization process. A great interest to further develop this technique is evoked for further reduction in feature size and fabrication cost.

As the dimension of semiconductor devices becomes smaller and smaller, deep sub-half micron technique, for example, a line width of 0.25μm, or even 0.18μm, is used. To planarize the wafer surface by chemical-mechanical polishing, especially to planarize the oxide layer within in a trench, becomes more and more important. To prevent the formation of a recess on the surface of the oxide layer within a shallow trench isolation of a larger area, a reverse tone active mask is used in process. An etch back process is also performed to obtain a better chemical-mechanical polishing uniformity. However, a misalignment often occurs.

In a conventional process of forming a shallow trench isolation, since the active regions have different dimensions, the dimensions of shallow trench between active regions are different. In Fig. 1A to Fig. 1E, a cross sectional view of the process for

forming a shallow trench isolation by chemical-mechanical polishing is shown. In Fig. 1A, a pad oxide layer 15 and a silicon nitride layer 16 are formed on a substrate 10. Using photolithography and anisotropic etching, a shallow trench 14 and an active region 12 are formed. The dimensions of the shallow trench 14 are various according to the various dimensions of the active region 12.

In Fig. 1B, using atmosphere pressure chemical vapor deposition (APCVD), an oxide layer 18 is formed over the substrate 10 and fills the shallow trench 14. Due to the topography of the shallow trench 14 within the substrate 10 and the characteristics of step coverage of the oxide layer 18, the surface of the deposited oxide layer 18 is undulating but smooth. A photo-resist agent is coated on the oxide layer 18. Using photolithography, a reverse tone active mask 20 is formed. The reverse tone active mask 20 covers the surface of the shallow trench 14 and becomes complementary to the active regions 20. It is known that during the formation of the reverse tone mask 20, a misalignment often occurs. Consequently, the reverse tone active mask 20 covers a range of the oxide layer 18 beyond the shallow trench 14.

In Fig. 1C, the exposed part of the oxide layer 18, that is, the part which is not covered by the reverse tone active mask 20, is etched away until the silicon nitride layer 16 is exposed. The resultant structure of the oxide layer is denoted as 18a. As shown in the figure, the oxide layer 18a covers most of the shallow trench 14 and a small part of the silicon nitride layer 16 on the active region. In Fig. 1D, the reverse tone active mask 20 is removed. It is found that a recess 22 is formed since the oxide layer 18a does not covered the shallow trench 14 completely.

In Fig. 1E, the oxide layer 18a is polished by chemical-mechanical polishing

until the oxide layer 18a has a same level as the silicon nitride layer 16. In addition, it is obvious that the recess 22 is formed since the oxide layer 18a does not fill the shallow trench 14 completely. A kink effect is thus easily occurs by the recess 22. That is, a current leakage or a short circuit is caused. The yield of the wafer is affected.

Therefore, in the semiconductor manufacture process, it is very important how to improve the issue that the oxide layer, filled into the shallow trench, cannot completely fill the shallow trench due to the misalignment of the reverse active mask during the CMP process. Particularly, as the technology trends to minimize the line pitch of the device, how to overcome this problem and increase the yield rate of chips to reduce the cost is a desideratum.

It is therefore an object of the invention to provide a method of forming a shallow trench isolation by chemical-mechanical polishing incorporating a high density plasma chemical vapor deposition (HDPCVD) with a partial reverse active mask. The shallow trench isolations have various dimensions in accordance with the dimensions of the active regions therebetween. An oxide layer formed by HDPCVD has a pyramid-like profile on the active region. Therefore, this oxide layer is easier to be planarized by chemical-mechanical polishing than an oxide layer form by conventional APCVD. The central part of an oxide layer on an active region of a large area is removed. Whereas the oxide layer on an active region of a small area is remained. A uniformity is thus obtained for chemical-mechanical polishing. Consequently, the recess and misalignment caused by reverse tone effect are avoided.

To achieve these objects and advantages, and in accordance with the purpose of

the invention, as embodied and broadly described herein, the invention is directed towards a method of forming a partial reverse active mask. A mask pattern comprising a large active region pattern with an original dimension and a small active region pattern is provided. The large active region pattern and the small active region pattern are shrunk until the small active region pattern disappears. The large active region pattern enlarged to a dimension slightly smaller than the original dimension.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A to Figure 1E are cross sectional views, on which a conventional method of forming a shallow trench isolation by reverse tone active mask is shown;

Figure 2A to Figure 2E are cross sectional views, on which a method of forming a shallow trench isolation by partial reverse active mask according to the invention is shown; and

Figure 3A to Figure 3D show a method of forming a partial reverse active mask according to the invention.

Elements represented by numbers in the drawings are described as follows

10, 40: substrate

12, 42: active region

14, 44: shallow trench

15, 45: pad oxide layer

16, 46: silicon nitride layer

18, 18a, 48, 48a, 48b, 48c: oxide layer

20: reverse active mask

22: recess

42a: the central part of the active region

50: small active region pattern

60, 60a, 60b: large active region pattern

62, 62a, 62b: small active region pattern

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the invention, using HDPCVD incorporating with partial reverse active mask and chemical-mechanical polishing, a shallow trench isolation is formed. The formation of a recess due to misalignment of reverse tone active mask and a short circuit or a leakage current caused by a kink effect caused are avoided.

In Fig. 2A to Fig. 2E, a method of forming a shallow trench isolation in a preferred embodiment according to the invention is shown. In Fig. 2A, active regions 42 are formed on a substrate 40. A pad oxide layer 45 and a silicon nitride layer 46 are formed on the substrate 40. Using photolithography and etching, the pad oxide layer 45, the silicon nitride layer 46, and a part of the substrate 40 are defined to form a shallow trench 44 between the active regions 42. The dimension of the shallow trench 44 is variable corresponding to the active regions 42. In Fig. 2B, using HDPCVD, an oxide layer 48 is formed over the substrate 40. Due to the shallow trench 44, the oxide layer 48 formed by HDPCVD has a profile, of which a pyramid-like structure is formed

on the active regions 42.

In Fig. 2C, a photo-resist layer is formed on the oxide layer 48. Using photolithography and etching, the photo-resist layer is defined into a partial reverse active mask 50. In addition, an opening 52 formed on a large active region 42a to expose the oxide layer 48 thereon. Since only the oxide layer 48 on the central part of the active region 42a is exposed within the opening 52, even a misalignment occurs to cause a shift of the partial reverse active mask 50, the oxide layer 46 on the shallow trench 44 is not exposed.

In Fig. 2D, the exposed oxide layer 48 within the opening 52 is etched back until the silicon nitride layer 46 is exposed. The partial reverse active mask 50 is stripped. The remaining oxide layer on the small active region 42 is denoted as oxide layer 48b, whereas the remaining oxide layer on the large active region 42a is denoted as 48a. The remained oxide layers 48a, 48b have no a continuously large and a high profile, so that can be easily polished in the subsequent CMP process. The uniformity of the CMP process can be increased.

In Fig. 2E, using chemical-mechanical polishing, the oxide layer 48b and the oxide layer 48a having a pyramid-like profile are planarized with the silicon nitride layer 46 as an etch stop, so that the oxide layer 48 within the shallow trench 44 has a same level as the silicon nitride layer 46.

In the above embodiment, a partial reverse active mask is employed for forming a shallow trench isolation. In Fig. 3A to Fig. 3D, a method of forming a partial reverse active mask is shown. As shown in Fig. 3A, to define a photo-mask pattern, active regions are formed first. The active regions include a large active region pattern 60

and a small active region pattern 62. In Fig. 3B, the large active region pattern 60 and the small active pattern region 62 are shrunk as shown in the figure. The shrinking large active region pattern and the shrinking small active region pattern are denoted as 60a and 62a respectively.

In Fig. 3C, the shrinking process is continued until the shrinking small active region pattern 62a disappears. The shrinking distance is about 0.5μm to 2μm each side. At this time, only the shrinking large active region pattern 62a is left.

In Fig. 3D, the shrinking large active region pattern 62a is enlarged with a dimension of about 0.2μm to 2μm each side. This enlarged dimension is smaller than the shrinking distance mentioned above. The resultant active region pattern is shown as the figure and denoted as 60b. It is seen that the resultant active region pattern 60b is slightly smaller than the original active region pattern 60. By applying this photo-mask pattern in forming a shallow trench isolation, the central part of an active region is exposed, whereas the edge part of the active region is covered by a photo-resist. A partial reverse active mask pattern is thus obtained.

The advantages of the invention are:

(1) Using a partial reverse active mask to etch away the oxide layer on the central part of an active region, only the oxide layer on the edge part of the active region and on a small active region is remained. The remained oxide layers have no a continuously large and a high profile, so that can be easily polished in the subsequent CMP process. The uniformity of the CMP process can be increased.

(2) Since only the oxide layer on the central part of an active region is etched away by using a partial reverse active mask, even when a misalignment occurs, the

oxide layer within the trench is not etched. The kink effect is prevented. As a consequence, the current leakage and the short circuit caused by kink effect are avoided, so that the yield of wafer is enhanced.

Other embodiment of the invention will appear to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples to be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.